§25. Erosion Properties of Tungsten at Elevated Temperature

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Enhanced erosion of low-*Z* metals such as beryllium and lithium due to the formation of loosely bound surface adatoms has been observed at elevated temperatures under plasma bombardment in the linear divertor plasma simulator PISCES-B[1]. On the other hand, the existence of enhanced erosion of high-*Z* metals like tungsten (W) and molybdenum (Mo) at elevated temperatures is not confirmed yet; two contradictory experimental results have been reported[2), 3)]. Thus, we aim to investigate erosion properties of high-Z metals at elevated temperatures for better predictions of the lifetime of high-Z metal walls in future fusion reactors.

Using the newly installed material probe system located at the 10.5L port, a castellated W target (80 mm x 30 mm x 1.5 mm) was exposed to divertor plasmas in the Large Helical Device (LHD) for 68 s in total. The time evolution of erosion and the surface temperature was measured with two small spectrometers (Avantes) placed at the 10.5U port. In addition, two-dimensional measurements of the target temperature were performed with an infrared camera from the 10.5U port.

Like in the 16th campaign, W line emission associated with W erosion was not observed, since the W target temperature did not increase to a high enough range. Instead, strong line emission of Mo was seen, since a Mo bolt used to fix the W target was accidentally exposed to divertor plasmas and was sufficiently heated up. Fig. 1 shows the time evolution of normalized Mo I line intensities and a ratio of black body radiation intensities at 800 nm and 950 nm. Note that the black body radiation ratio is related to the surface temperature and increased during the plasma exposure. This indicates that the surface temperature is expected to increase. Furthermore, the Mo I line intensity normalized to intensities of background plasma species (H, He^{+}, and C^{2+}) increased with time. This means that erosion of Mo increases due to the surface temperature increase. The surface temperature will be evaluated from black body spectra after the absolute intensity calibration of the spectroscopic system. This will enable us to identify the mechanism of the observed enhanced erosion of Mo, i.e. whether the formation of surface adatoms is critical or not.

A photo of the W target after the plasma exposure is shown in Fig. 2. It is seen that a melted Mo bolt flowed onto W. It seems that the direction of the melted Mo layer flow is determined by the summation of *JxB* force and plasma pressure. On the other hand, *JxB* force was dominant in the W melt experiment in the TEXTOR tokamak[4]. The difference can be explained by the different melting points. The melting temperature of Mo, T_m(Mo) = 2896 K, is lower than that of W, T_m(W) = 3695 K, and thus the thermionic electron emission current around T_m(Mo) is much smaller than that around T_m(W). As a consequence, it is thought that the *JxB* force in this experiment was smaller, and became comparable to the plasma pressure.

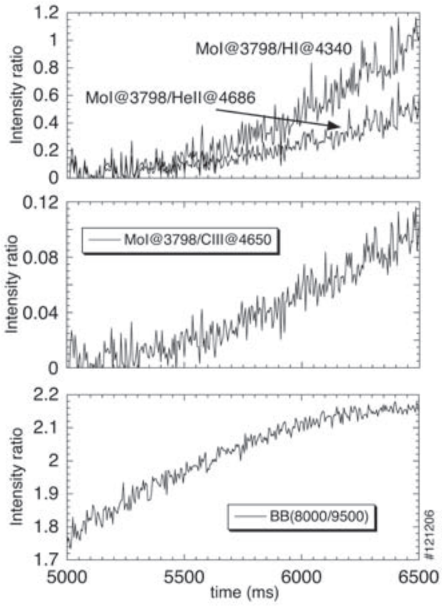

Fig. 1. Time evolution of normalized Mo I line intensities and a ratio of black body radiation at 800 nm and 950 nm.

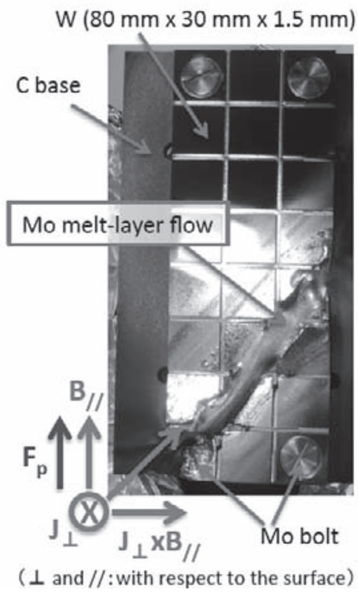

Fig. 2. Photo of the castellated W target after the LHD divertor plasma exposure for 68 s in total.

1) Doerner, R.P. et al.: J. Appl. Phys. **95** (2004) 4471.
2) Sergienko, G. et al.: presented at EPS 2005.
3) De Temmerman, G. et al.: presented at PSI 2012.
4) Coenen, J.W. et al.: Nucl. Fusion **51** (2011) 083008.